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The American Journal of Roentgenology

Edited by P. M. Hickey, M. D.
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THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor, P. M. Hickey, M. D., Detroit
Associate Editor, F. C. Zapffe, M. D., Chicago

VOL. II MARCH, 1915 No. 5

SOME EXPERIMENTS AND OBSERVATIONS ON TECHNIQUE FOR DEEP ROENTGENOTHERAPY*

By GEORGE E. PFAHLER, M. D., Philadelphia

Precision is the constant aim of the modern roentgenologist. The more accurately we measure every detail of our work, the more certain will be our results. The more we know of the effect of the rays under all varying, but measurable conditions, the more definitely can we reproduce our results, and the more easily adapt our technique to the special needs of any particular patient.

The most practical means of measuring dosage of the rays that have yet been devised are the Sabouraud-Noire pastilles of barium platino-cyanide and the Kienböck strips of photographic paper. These were devised before the days of filtration, and each measured the dose required to produce a mild erythema, or alopecia.

The greenish tint of fresh barium platinocyanide paper is changed to a brownish yellow, which is called "Tint B" and equals the full dose of skin toleration. The same dose is recorded by the tenth shade of Kienböck's paper, and is spoken of as 10 X.

The Sabouraud pastilles were placed midway between the target of the tube and the skin of the patient. The Kienböck photographic paper was placed on the skin.

Since filtration forms such an important part of our present day technique it is necessary to readjust our estimate of dosage and make some accurate experiments under definite conditions in order to know at each particular moment what we are accomplishing. For if we do too little we accomplish nothing, and if we do too much great harm will result.

Since we now have outfits capable of giving almost a uniform output under definite circumstances, it is only necessary to know the value of each factor in order to reproduce at will the quality and quantity of rays needed for any definite result. The Coolidge tube is the new factor that has made these experiments possible, and has been used in all of them.

In order to eliminate the possibility of decomposition of imported papers I decided to standardize one of our high grade domestic papers. For this suggestion I am indebted to Dr. Howard Pirie of Montreal, who had already done this for his own laboratory, and then recommended it to me in a private communication.

For this purpose I use Normal Glossy Cyco, which is developed after exposure for one and one-half minutes in the following developer: Metol 20 grs., Hydrochinon 80 grs., Sodium sulphite (crystals) 2 ozs., Sodium Carbonate (crystals) 2 ozs., 10% sol.

*Read before the Annual Meeting of the American Roentgen Ray Society, Cleveland, Ohio, September 9, 10, 11, 12, 1914.

NOTE—Owing to the fact that the slip containing the test papers was mislaid in the printing office, this article has had to be published without appropriate illustrations, as the making of the tests involves so much time that Dr. Pfahler thought it impossible to make them again.

of Potassium Bromide 30 minims, using one part to seven parts of water at 70 degrees temperature. It is then placed in plain hypo solution 1 to 4 for one minute. It is then washed for 15 minutes in running water and dried.

In order to standardize my shades I first tested my Sabouraud pastilles and my Kienböck strip by using them in the treatment of ringworm, treating each area until I had produced Tint B, and then recording the shades of photographic effect on the Kienböck paper.

I then, under definite conditions of my outfit found the time required to produce Tint B on the Sabouraud pastille, and 10 X on the Kienböck photographic paper. I then divided this time into ten equal units and exposed a sheet of paper to the rays for from one to ten units of this time, protecting the remainder of the paper during each exposure. In this way I obtained a graduated scale of 10 shades each representing one Kienböck unit or one-tenth of a full, or erythema dose of unfiltered rays.

The transformer, and the Coolidge tube, with 10 m. a., running constantly, with the current brushing over a parallel spark gap of 7 inches, with the target 8 inches from the surface required 30 seconds, with no filter.

The forty-plate static machine (Toeplar-Holtz type), with a similar spark gap (brushing) between the wires, but only four inches between the balls on the parallel bars, and with an output of 4 m. a., required 100 seconds.

As a result of this standardization I shall take the liberty of estimating my quantity of rays in Kienböck units.

Experiment No. 1: To determine the relative absorptive value of 2½ inches of water, and 2½ inches of beef liver.

Coolidge Tube: Spark gap 6 inches; distance from target to bottom of containers, 8 inches; 3 m. m. of aluminum, with a series of exposures of from one to five minutes, with 10 m. a. of current from a transformer, and with the secondary current constant.

This showed (1) more absorption of rays by the liver than the water; (2) only about 1 X, at the end of 5 minutes under the liver, and 2 X under the water, while on the same levels as the base of these containers under the like conditions 10 X is registered in one minute.

This teaches that only about 1/50 of the surface dose of the rays will reach 2½ inches in depth of liver tissue, even when filtered through 3 m. m. of aluminum. It must be borne in mind that in treating through the abdomen the fat and intestines probably absorb less than water, and even muscle less than liver.

Experiment No. 2—Fig. 1: To determine the relative value of the radiation at the surface, and at one, two, three, and four inches in depth of tissue.

For this purpose I at first used beef liver sliced one inch in thickness and piled upon one another. The sliding of the layers made this unsatisfactory.

I then used Hamburger steak packed solidly in boxes to the depth of one inch and used five such boxes. The five boxes were placed upon a lead base, which was 13 inches from the target. The surface of the first box was 8 inches from the target, which is a fair working distance for practical treatment.

The layers were therefore respectively 8 (surface), 9, 10, 11, 12, 13 inches from the target and at each of these test papers were placed. The series of 10 test papers at the surface were exposed respectively from 10 to 100 seconds, each increasing by 10 seconds. A series of 10 were exposed under each layer of meat, from 1 to 10 minutes respectively.

I used 10 m. a. of transformer current, with a parallel spark gap resistance of 7 inches, and 3 m. m. of aluminum as a filter.

This series showed that 5 X were recorded on the surface in 30 seconds, at one inch in depth in one minute; at 2 inches in depth in 4 minutes; at 3 inches in depth in 6 minutes; at 4 inches in depth in 8 minutes, and at 5 inches in 10 or more minutes. The degree

of radioactive effect for the varying exposures under the 4 and 5 inches of meat was not clearly shown, and I believe that the effect is much less than the above indications, probably not more than half, which would agree with Experiment No. 1.

This experiment represents a lot of work and yet is not entirely satisfactory. I would have repeated it again if time would have permitted.

In a general way it indicates a decrease by 50% with each successive inch in depth.

EXPERIMENT NO. 3—FIG. 2: To determine the relative value of the constant secondary transformer current, and that interrupted by means of a rhythmeur.

This showed that when the time of exposure was equal to the time of the interval that the exposure to obtain a desired effect was just twice as long as when the secondary transformer current was allowed to flow through the tube constantly. This is what one should expect, but the experiment was done because it has been claimed that the time required was not much increased.

Therefore the only advantage of the use of a rhythmeur is to permit the gradual cooling of the tube, and yet no direct interruption of the treatment of the patient to give any single dose. I find it an advantage when using the Coolidge tube.

EXPERIMENT NO. 4—FIG. 3: To determine the relative absorption of from one to six millimeters of aluminum. Exposure 30 seconds for each, 10 m. a., spark gap 7 inches, distance 8 inches.

No filter=10 X
1 m. m.= 4 X
2 m. m.= 3 X
3 m. m.= 2 X
4 m. m.= 1 X
5 m. m.= 1 X
6 m. m.= 1 X

The last three were indistinguishable, and are probably less than 1 X. This experiment should be repeated with longer exposures. It however illustrated the law laid down by Walter in 1905 that the first layer of a substance absorbs most of the rays peculiar to that substance, and which led to my recommendation of the leather filter, before this organization during the same year.

EXPERIMENT NO. 5—FIG. 4: To test the relative value of rays (unfiltered) with varying parallel spark gap (Coolidge Tube).

10 m. a., spark gap 10 in.—8 in. dist., no filter—15 sec.—10 X
10 m. a., spark gap 9 in.—8 in. dist., no filter—15 sec.— 9 X
10 m. a., spark gap 8 in.—8 in. dist., no filter—15 sec.— 7 X
10 m. a., spark gap 7 in.—8 in. dist., no filter—15 sec.— 5 X
10 m. a., spark gap 6 in.—8 in. dist., no filter—15 sec.— 4 X
10 m. a., spark gap 5 in.—8 in. dist., no filter—15 sec.— 2 X
10 m. a., spark gap 4 in.—8 in. dist. no filter—15 sec.— 1 X

It will be seen that, other factors being equal, the value of a ten inch parallel spark gap is twice as great as a seven inch parallel spark, and that a vacuum resistance equal to a seven inch spark will produce more than twice as much radioactive effect as one backing up five inches, also that the value is ten times as great with a parallel spark of ten inches as with one of five inches.

This is a most important observation for practical work and argues most forcibly in favor of outfits that will permit of this high resistance, for it is these same conditions that give us our most valuable penetrative rays for deep work. The penetrative value of these rays corresponds numerically to the Benoist scale, i. e. 7 inch spark gap=7 B, 8 inch spark gap=8 B, 9 inch spark gap=9 B, 10 inch spark gap=10 B.

EXPERIMENT NO. 6—FIGS. 5, 6, 7: To determine the relative deep value of rays, filtered through 3 m. m. of aluminum, with varying parallel spark gap, all other factors remaining the same and similar to those in Experiment No. 5, except that the exposures were 1 minute instead of 15 seconds. Finely chopped and thoroughly packed meat was used.

At one inch in depth, a 10 inch spark gap gave 7 X, a 9 inch spark gap gave 5½ X, an 8 inch spark gap gave 4 X, and with 7, 6, 5 and 4 inch the value was hardly determinable.

At two inches in depth, a 10 inch spark gap gave 3 X, a 9 inch spark gap gave 2 X, and an 8 inch spark gap gave 1 X, a 7, 6, 5 and 4 inch gave progressively less than 1 X.

At three inches in depth, a 10 inch spark gap gave 2 X, a 9 inch spark gap gave 1 X, an 8, 7, 6, 5 and 4 inch spark gap gave progressively less than 1 X.

It will be seen that the rays of greatest value at one and two inches in depth are those from a tube with a resistance equal to 10, 9 or 8 inches and below this point the rays are almost worthless, while at 3 inches in depth only those from a 10 and 9 inch resistance are of appreciable value.

EXPERIMENT No. 7: Test of the deep value of rays as influenced by filters placed above the surface, from one to seven m. m. of aluminum.

For this experiment three inches of meat were placed upon a sheet of cyco paper. The target of the tube 8 inches from the surface of the meat. At 4 inches from the target were placed from 1 to 7 m. m. of aluminum as filters. With each variation of filters one-seventh of the paper was exposed for four minutes, with a 10 m. a. of transformer current, and a tension equal to 9 inch spark gap.

With the above conditions, at the bottom of 3 inches of meat, and with 1 m. m. of aluminum 5 X were recorded. There was then very little reduction in value with the addition of filters up to 7 m. m.

This teaches us that in deep work our deep value of rays is very slightly diminished by the filters, since the quality of rays absorbed by the filters would otherwise have been absorbed by the upper layers of meat.

This same experiment was repeated with 1 inch of meat, and 1 minute exposures and with the same conclusions.

The study of this experiment naturally raises the question as to whether there was not a general fogging from secondary radiation. The next experiment will answer this in the negative.

EXPERIMENT No. 8: To determine the relative value of secondary radiation given off from the meat.

For this 3 inches of meat were packed in three 5 x 7 inch plate boxes. The target was placed 8 inches from the surface, and all the rays passed through a cylinder 2 inches in diameter. This cylinder was centered so that its circumference was 1, 1, 2, and 4 inches respectively from the four sides of the box. At each side of the box was placed a sheet of cyco paper and a Cramer X-ray plate. With a current tension equivalent to 8 inch spark gap, 10 m. a. of current an exposure of three minutes, through 3 m. m. of aluminum, caused the plates to be so densely blackened as to be unable to see through them with the ordinary illumination box. The paper however showed no effect on any side.

This showed that the meat gave off considerable secondary radiation, and I was anxious to record this in Kienböck units. I therefore repeated the experiment using twenty minutes' exposure instead of three. Still only the slightest fogging was shown on the paper at a distance of one inch from the outer surface of the cylinder. This was not more than one-tenth of 1 X. It must be realized that this extremely slight secondary ray effect was obtained with a surface dose of 400 X, and with a dose at a depth of 3 inches to 20 X.

Therefore we are justified in concluding that the secondary radiation had no effect on the results in Experiment No. 7. Of far more practical importance is the conclusion that secondary radiation must be ignored in estimating one effect in deep therapy. No well informed roentgenologist will at present doubt the existence of secondary radiations, and while they can not be ignored photographically, they are comparatively so insignificant as to be useless therapeutically at least as given off from the flesh.

EXPERIMENT No. 9: To test the amount of secondary radiation given off by the walls, and the air in the vicinity of an active Coolidge tube.

For this purpose I placed Cramer X-ray plates on the walls, both above and below the lead protection, in adjacent rooms to the one which contains the active tube. At the end of a day's work the plates were developed and they were so dense that they

would not transmit the light from an illumination box. I then used a similar arrangement and had them developed after the tube was in use only 12½ minutes. There was a decided fog on all, and one which was above the lead screen was quite black.

At the end of a day's work, a plate which was suspended in the air in the centre of an adjoining room was absolutely black, though it received no direct rays, and was 8 feet from the partition containing the lead. This work is not complete.

CONCLUSIONS

Some of these experiments should be repeated and others elaborated upon, still I feel that the following conclusions can be drawn:

1. The denser portions of the body, especially the liver, absorb considerably more rays than an equal thickness of water. The liver absorbs twice as much.

2. Only about one-fiftieth of the rays which are filtered through 3 m. m. of aluminum, and corresponding to 6 to 7 B in penetrative value will pass through 3 inches of meat. Therefore to obtain the equivalent of an erythema dose at three inches in depth we must cross fire at this deep point fifty times. Fortunately with these well filtered rays, under careful management, we can give from 20 X to 30 X on the surface, which will reduce correspondingly the number of areas through which we must treat.

3. A rhythmeur which interrupts the secondary current for a definite time at definite intervals does not increase the relative value of the rays from a Coolidge tube—a tube with a vacuum which remains constant under definite conditions. Its value lies in the interval which permits cooling, and permits the giving of a full dose without complete interruption of the treatment and annoyance of the patient.

4. The absorptive value of aluminum filters does not correspond progressively with the number of millimeters used. The first millimeter absorbs nearly as much as the next two.

5. The most valuable rays for deep Roentgenotherapy are produced by a vacuum which corresponds to a 10 inch spark gap, or will record 10 on the Benoist penetrometer scale. The rays below 8 are relatively almost valueless for effects three inches in depth.

6. The value of rays at three inches in depth is not much reduced by any number of millimeters of aluminum up to seven.

7. The secondary radiation in an adjoining room to the one used for treatment is a very decided factor to be reasoned with in connection with our photographic work, and perhaps with regard to our personal protection, especially since this radiation seems to be greatest in free air.

THE DESIRABILITY OF COMPLETE IMMOBILIZATION IN ROENTGENIZATIONS OF THE HEAD

By DR. PERCY BROWN, Boston, Mass.

The application of Roentgen rays as a diagnostic agent in accessory sinus disease has now been employed for some years with gradually increasing success and, it is believed, with gradually increasing value and satisfaction to the clinician. The technique of successful investigation of cranial mural structures and of the intracranial contents is, without much question, the most difficult the Roentgenologist is compelled to surmount. That this technique must be difficult is evidenced from the fact that, even from the most dependable Roentgenologists, records of uniform excellence are seldom obtained and, from less completely trained men, good diagnostic results are practically never forthcoming. The cause of this difficulty has been attributed to many factors, chief among these being the apparent obstacles met with in projecting the X-rays through structures at once so deep and so hard. After constant practice in capital Roentgenology and the problems which it engenders, the writer has become inclined to the belief that the technical difficulties arising in this work are not so much due to the inimical factors of anatomical depth and density, but are due rather to factors much more personal and subjective in their nature and which are apparent enough upon a moment's consideration of the matter.

As an elaboration of his belief, thus mentioned, the writer has come to feel that a large part of the relative non-success of this beautiful diagnostic procedure is caused by the discomfort, apparent or real, personally sustained by the subject under examination. This discomfort, if such it be, is, of course, by no means real in the sense that pain or true bodily embarrassment is produced. It is, on the other hand, the mental discomfort, if you will, produced in many individuals by an effort to hold any part of the body in complete immobilization. In the writer's experience, this effort produces what a neurologist might term an "intention tremor," and it is especially noticeable when an attempt is made to control movements of the head. Too much, then, is left to the responsibility of the patient in this respect and, consequently, failure of the method appears in

direct proportion to the mental and nervous instability of the subject under examination. It is a well-known fact that a large element of success in obtaining records by Roentgen rays depends upon the closeness and firmness with which the plate or film to be recorded upon can be approximated to the part in question. This principle applies even more closely to the region embracing the accessory nasal sinuses. The patient, therefore, is always asked to make as firm pressure as possible upon the plate, especially when the antero-posterior projection of these sinuses is to be obtained. Instead of producing the desired effect, however, the subjective intention, notwithstanding it may be the best of intentions, produces a tremor which, when sustained over a period of the few seconds necessary to make the exposure, is disastrous in its results. In short, the patient, while endeavoring to be passive, is actually maintaining an active part in the production of the desired record. Furthermore, the maintenance of this relative degree of activity, although it may be assumed by the patient quite unconsciously, is equally unfavorable when an attempt is made completely and thoroughly to secure a proper co-relationship between plate, subject and the source of Roentgen radiation.

Stimulated by the sting of many untoward results in this wise incurred, and by the determination that some form of apparatus should be devised which would permit at once the proper application of Roentgen radiation to the regions under consideration and the temporary transformation of the patient for the purpose in hand into a mental and physical "wooden Indian," it has long been his belief that the pursuance of these investigations with the patient either in the prone or supine posture is totally out of accord with the possibility of securing perfect diagnostic results. While these postures may be for many patients the ones making for physical comfort, the very fact of being obliged to lie down for such an ordeal (as many patients at first believe it to be) is distinctly perturbing mentally, not to say terrifying. The upright position, therefore, naturally suggests itself as a means of dispelling the imaginary bugbear of the investigation. From the operator's point of view, likewise, the upright posture makes it much easier to secure the proper interrelation between Roentgen radiation, the recording element and the diagnostic region in question. If, for instance, pressure is desired at any point, it can be effected directly, by the operator and not by the patient, in a most indifferent way, at the request of the operator. In the ordinary methods of examining the head with Roentgen rays, a most important, and at the same time, a most variable factor, is almost universally neglected. The Roentgenologist, in accessory sinus investigations at least, to say nothing of others, is called upon to determine variation, whether anato-

mical or pathological, as between right and left. In his usual procedures to acquire this differentiative knowledge, he has been in the habit of assuming that the human skull is as constant and consistent in its dimensions as the geometrical cube. He is very apt totally to neglect the almost constant individual change in maxillary angle, in facial angle, in frontal angle and all other anatomical variants pertaining to the skull. Most of all, however, he is prone to disregard the variation in angulation between Reid's base line and the many mural deviations of the skull, especially in the region of the face. The necessity for the recognition of these variations has been long since pointed out by Caldwell, but the daily practical application of such necessary steps has been made difficult on account of the fact that, as has been said, the patient in a disquieting posture has been asked to maintain subjectively the much-to-be-desired and often complex anatomical relationships.

The apparatus to be shown you to-night is, therefore, an effort on the part of the writer and his laboratory assistants to produce mental comfort on the part of the patient, and on the part of the operator the comfort borne of the knowledge that his adjustments can and shall be maintained by the patient *nolens volens*. By this remark it is not intimated that this apparatus is in any way akin to the photographer's chair of our youth. In fact, it is destined to produce just the reverse impression in that by its application the patient is made to feel secure and irresponsible. He, therefore, resigns himself to the mental comfort of this assurance and his impulses to move are quickly dispersed from his mind.

In argument, it might be asked why, in these days of relatively short exposures to X-rays for diagnostic purposes, is it necessary to lay so much stress upon the importance of immobilization? In answer, it is repeated that there is no exposure so short that can fail to record fibrillary tremors, uncontrollable and almost involuntary, especially of the head.

The two specific purposes for which this apparatus was designed were, of course, a proper portrayal of the vastly important antero-posterior projection of the accessory sinuses, and, second, a similar correct projection of the lateral projection of these sinuses, with especial reference to the sphenoid region. It was attempted also to make this apparatus applicable for the projection of the base of the skull in such a manner that the hypophyseal region should be most clearly delineated. The relations between sphenoidal sinus and the pituitary fossa are such that the Roentgen technique for one applies to the other when the skull is projected laterally. True differentiation, however, of the right and left sphenoidal aspects can be obtained only from the skull projected antero-posteriorly, after the method of Pfahler. Since the erect posture was the chief desideratum, this contrivance takes the form of a chair. This chair may be

either built as a part of the apparatus or any stiff serviceable chair may be used and the sinus apparatus attached to it. The selection of the chair in the apparatus which shall be presented herewith, was largely experimental and in this case the so-called Risley chair was used. This chair, however, as a support for this apparatus, is a bit too narrow. The gross adjustments of this apparatus are as follows:

If the antero-posterior projection is desired the patient sits in the normal erect posture and the plate-holder acting in unison with the holder for the Crookes' tube, is lowered gradually to the level of the face. The plate-holder is then adjusted to the angle previously determined which is presented by the patient in question as the so-called relative angle of Reid's base line. The holder is then pushed backward toward the face and as it approaches the face it is adjusted more accurately and then pressed firmly down upon the face to the point of toleration. In the forward and back movement of the plate-holder, as in the vertical movement, the Crookes' tube-holder acts together with the plate-holder. The plate is now placed in the holder and clamps placed upon it to secure close approximation and the exposure made. The pressure upon the face is so great that while not being severe enough to cause discomfort to the patient, it produces a sense of security in immobilization which can be produced in no other way. If a stereoscopic pair of plates is desired of the antero-posterior projection of the accessory region, the Crookes' tube can be adjusted and released for the normal interpupillary excursion by means of a spring catch. The left plate can be changed to the right plate by hand. The pressure of the plate-holder upon the face secures immobility during the right and left stereoscopic exposure. When it is desired to project the skull in the lateral position for the purpose of investigating diagnostically the development of the frontal sinus, the posterior ethmoidal group, the sphenoid or the sella, an additional head support is attached and the plate-holder is applied, this time to the side of the face, in the same manner as before. Here the plane of the plate can be adjusted to the maxillary angle and to the lateral facial angle and the exposure made either plain or stereoscopically, as above described.

DARK ROOM ILLUMINATION

By E. W. CALDWELL, M. D.

The requirements of the Roentgen laboratory have brought about many improvements in dark room technique and equipment, some of which are being used by commercial photographers.

A few years ago all dark rooms were painted dead black in order to prevent reflection of actinic light. In the dark room which Dr. Leaming installed in the Rockefeller Institute several years ago, the walls and fixtures were made, as far as possible, pure white. The contrast between the clean white walls and the splendid illumination of this room when compared with the gloomy black of the traditional dark room is almost startling. It is obvious that if no light is admitted to this room, none will be reflected and hence such a room will be just as safe as a black dungeon. Moreover, when the room is illuminated by a *safe* red light, this light will be reflected readily from all of the white surfaces with the result that a satisfactory illumination of the entire room can be obtained with a light which has very small intensity and which is, therefore, relatively safe.

The success of the white room pre-supposes that absolutely no ray of white light shall enter the room when not desired. In most dark rooms some small crevice is likely to open up in the woodwork and admit a small amount of light. The danger of such a beam of light is, of course, enormously increased by reflections back and forth from white walls. It, therefore, occurred to me some years ago that we might obtain most of the advantages of Dr. Leaming's plan, without its disadvantages by painting the walls and fixtures red instead of white. A good red paint will reflect red light just as well as the white paint and, therefore, such a dark room will be illuminated just as easily by red light as the white one.

When it is desired to illuminate the room with white light the illumination will, of course, be inferior to that obtained with the white walls but very much better than can be obtained with the dead black walls, while the safety, for ordinary photographic materials, is quite as good as with the black.

The darker the red, the greater the safety will be, and the greater the difficulty of obtaining general illumination. For practical purposes I have found that pure red lead paint is very satisfactory. It is light enough in color to give good general illumination and reflects almost as little actinic light as black.

Following another suggestion of Dr. Leaming's, I have used indirect illumination for the dark room work. For this purpose any ordinary commercial type of indirect lighting fixture may be used with a ruby glass incandescent lamp. Care should be taken to paint the sealing-off tip of the lamp which often transmits white light. A very cheap and effective fixture may be made by suspending an ordinary drop light from the ceiling at a distance of about eighteen inches and hanging underneath this a deep tin baking pan which can be bought for a few cents. The red light from the ruby incandescent lamp is reflected by the tin against the red painted ceiling and then over the room, giving a very satisfactory illumination which we find sufficient even for our developing. Formerly we used a small ruby lamp, mounted on universal joints, for the purpose of examining negatives by transmitted light. We now find that with the abundant and perfectly safe illumination obtained with the indirect fixture above mentioned, we have

no need for transillumination during development.

The efficacy of the red paint as compared with the white can be tested by sticking a sheet of white paper over the red wall. When illuminated by the red light described, the red wall and the white paper seem to be exactly of the same color and brilliancy, proving that the red wall reflects as much of the safe light as the white sheet, although it reflects no more actinic light than black which, because it reflects neither, makes all illumination difficult.

LOSSES IN TRANSMISSION

By J. S. SHEARER, Cornell University

The article in the January number by Dr. VanZwaluwenburg on leakage, again brings forward a point often urged by the writer in discussing dosage measurement. In the November number of this Journal, attention was called to a measurement of leakage in a specific case where a steel tape was used between the milliammeter and the tube. In Fig. 2 of that article it is seen that on a 7-inch spark (about 73 K. V.), when the ammeter close to the tube read 1 M. A. the one at the other end of the tape read 2 M. A., or an error of 100%. This means that underdosage would result if the readings of the latter were taken. In the former article no discussion of reasons or remedy were given but it may be of interest to discuss briefly the question of proper wiring on the high voltage lines in order to reduce losses and make readings reliable.

Leakage is due either to current along the supports to which the wires are attached or to currents through the air between the wires or to the earth. The first is usually small if proper insulators are used and the wires are not too close together.

In Fig. 1, A. B. and C. D. represent an overhead system of transmission. P. Q. are transformer terminals and E. F. tube connections. An ammeter placed at (1) reads the entire current including *all leakage beyond* the ammeter, while at (2) it would

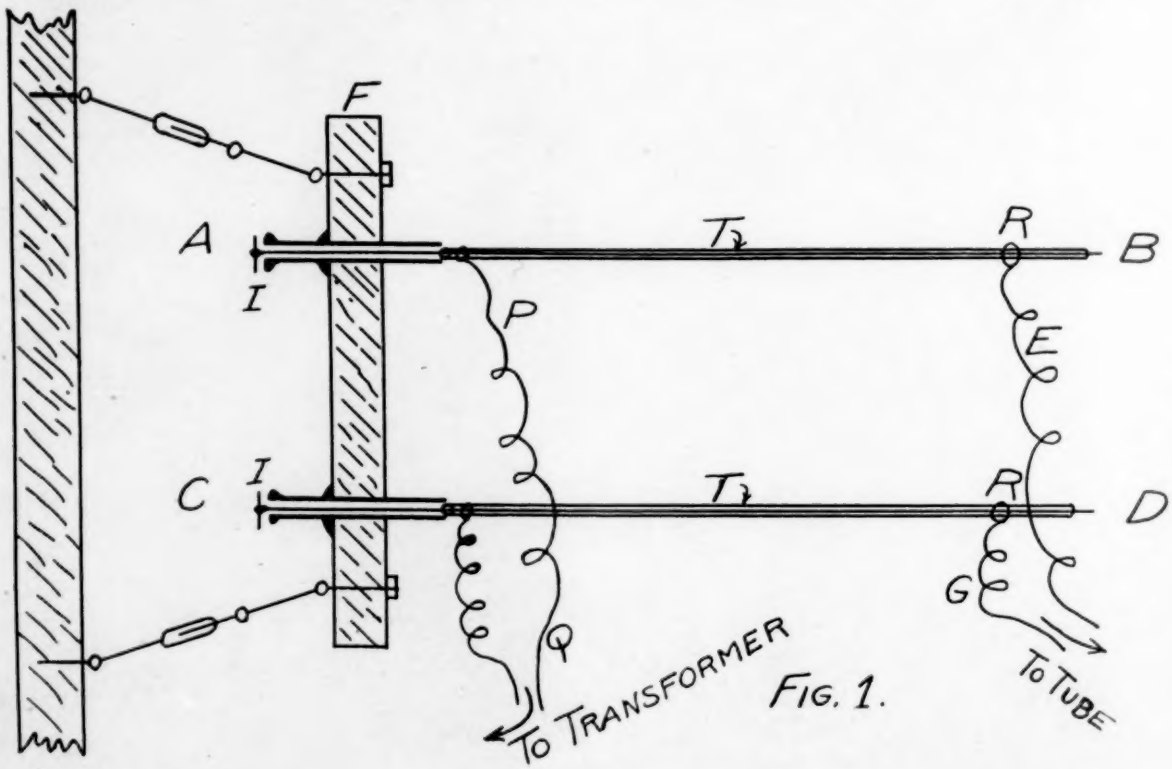


FIG. 1.

read current through the tube plus leakage from line between (2) and the tube. Evidently if the latter is short or is properly insulated this portion of the leakage may be greatly reduced.

Where it is not possible to work with the meter in the position (2) it is important to reduce the total leakage as far as possible and then to find by test the actual loss at the highest voltage used.

The leakage current between bare wires will increase: (a) with the decrease in distance between wires; (b) with reduction in diameter of the wire; (c) with the voltage between the wires; (d) with increase in length of lines; (f) with the nearness of uninsulated conductors. High tension lines should be at least 24 inches apart. Evidently where so many factors are present, one can hardly predict what the leakage will be since the condition of the air in the room is also a factor. The leakage from silk or cotton-covered wires may be much greater than from the same wire uncovered. On a line where the leakage amounted to 7 M. A. for an 8-inch spark it was reduced to a small fraction of a M. A. by slipping tin speaking tube over the wires, making the large radius tubing the real conductor.

A good arrangement is shown in Fig. 1. Thin brass tubes, T, ½ inch external diameter, are passed over iron telegraph wires, W. The wires are fastened to an insulator I and wires run from I through porcelain insulators in a 2″ x 3″ cross piece F. These porcelains have a shoulder so that no portion of the wire comes in contact with the wood. The cross arm may be attached to the wall by two iron wires with turnbuckles to give the required tension. The transformer may be attached to any convenient points in the system and the tube connections may be varied at will. The latter are best made by using guttapercha-covered wires soldered to inch metal rings, R R, which slide on the brass tubes.

If reels must be used they may be fastened to the end of the latter wires at a convenient height. In such an arrangement the leakage will be very small if proper wires are used to connect the transformer and tube to the line. A wire used by Dr. Caldwell and made by the Bishop Gutta Percha Co. (No. 74°C), 420 E. 25th, New

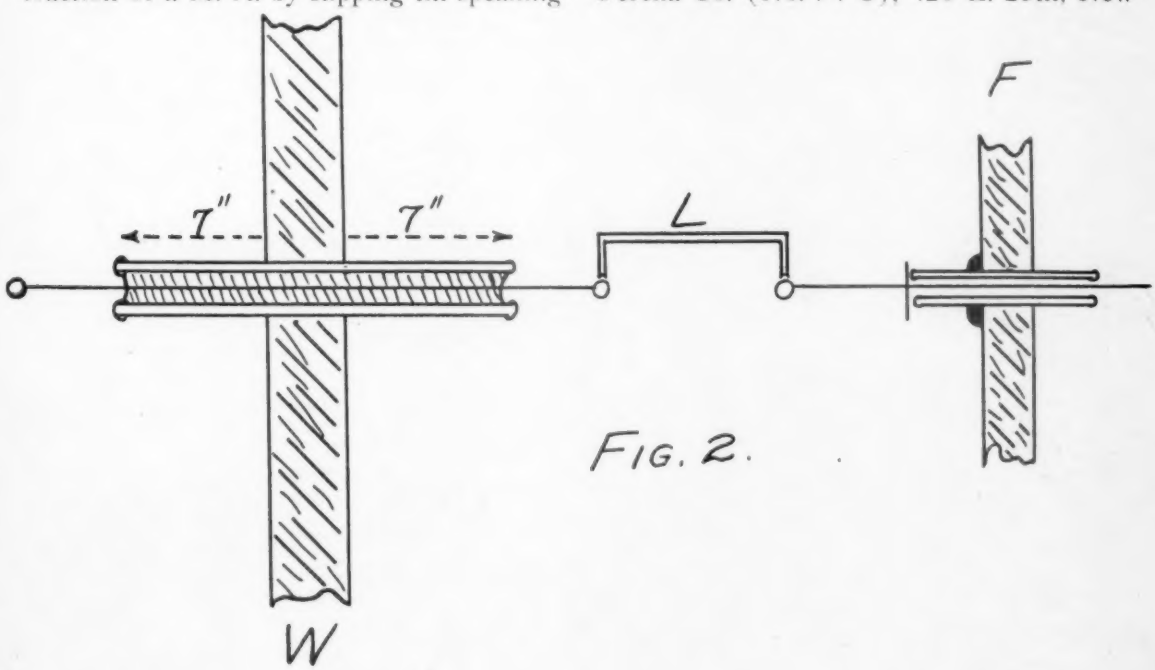


FIG. 2.

York, is very useful as it is flexible and cuts down leakage very well. Do not, however, allow the wires to come within 6 or 7 inches of each other as the insulation will puncture.

Such a system may be carried through walls into a dark room for fluoroscopy without difficulty. Large tubes (2″) of porcelain or micanite can be cemented into the wall. Fig. 2. A ¼ inch rod or tube is centered in this and the tube is filled with paraffine or insulating wax, rings soldered to the rod and similar rings on the end of the suspended system enable connecting links L, of tubing or guttapercha-covered wire to be used for coupling. Always avoid short edges and points. In this way a room may be disconnected from the main line when desired. The writer is convinced that when proper electrical measurements are substituted for pastilles and photographic papers, much greater certainty of dosage measurement will result.

A SUGGESTION ON THE USE OF THE COOLIDGE TUBE

Transformer Operation

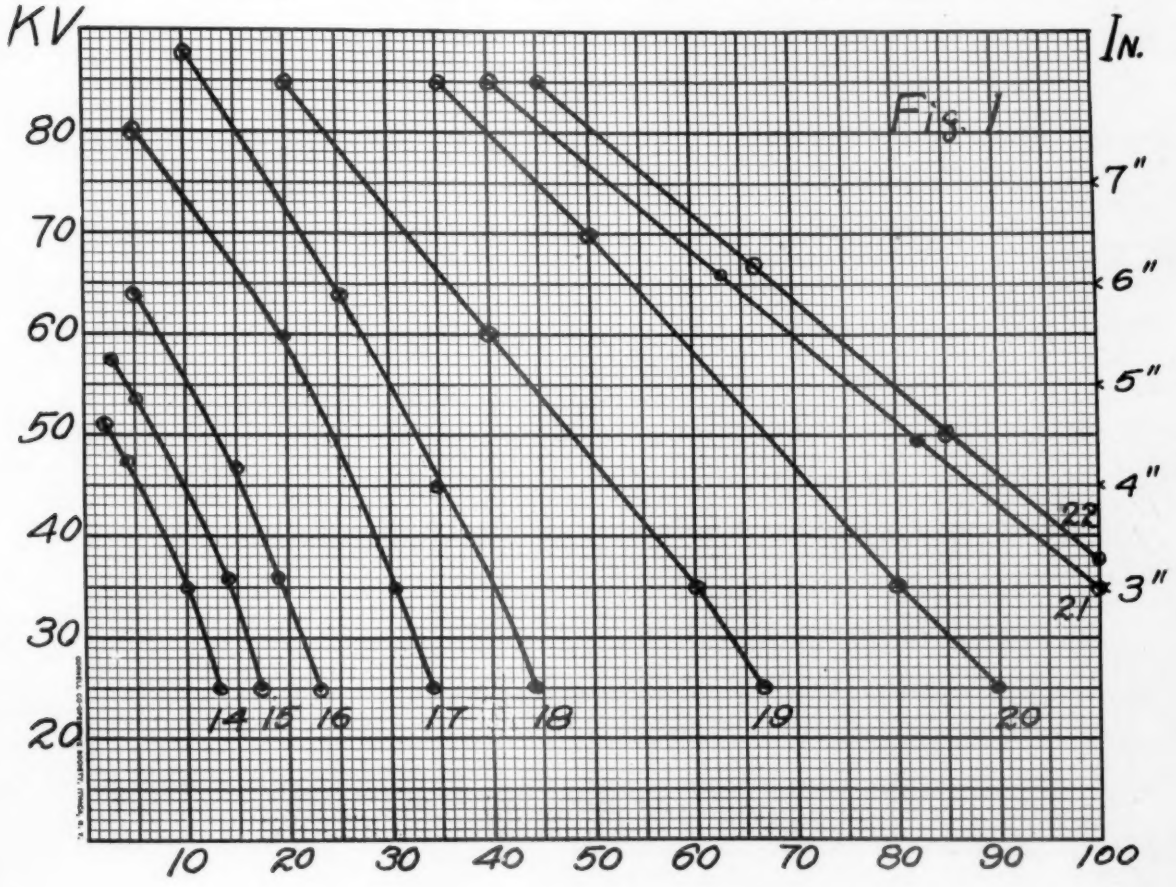
Rheostat Control

By J. S. SHEARER, Cornell University

The advent of the Coolidge tube has placed in the hands of the Roentgenologist a powerful and flexible tool by means of which results can be duplicated on a given installation without question.

To those who had become proficient in the use of the ordinary tube, however, the manipulation of the new device seems to offer considerable difficulty. The writer has had an opportunity to observe many operators using the tube and is convinced that the difficulties are due to failure to recognize the new conditions. This failure is not confined to operators alone but extends to many who endeavor to instruct.

There can be no doubt in the minds of those who have carefully observed the production of Roentgen radiation that when a

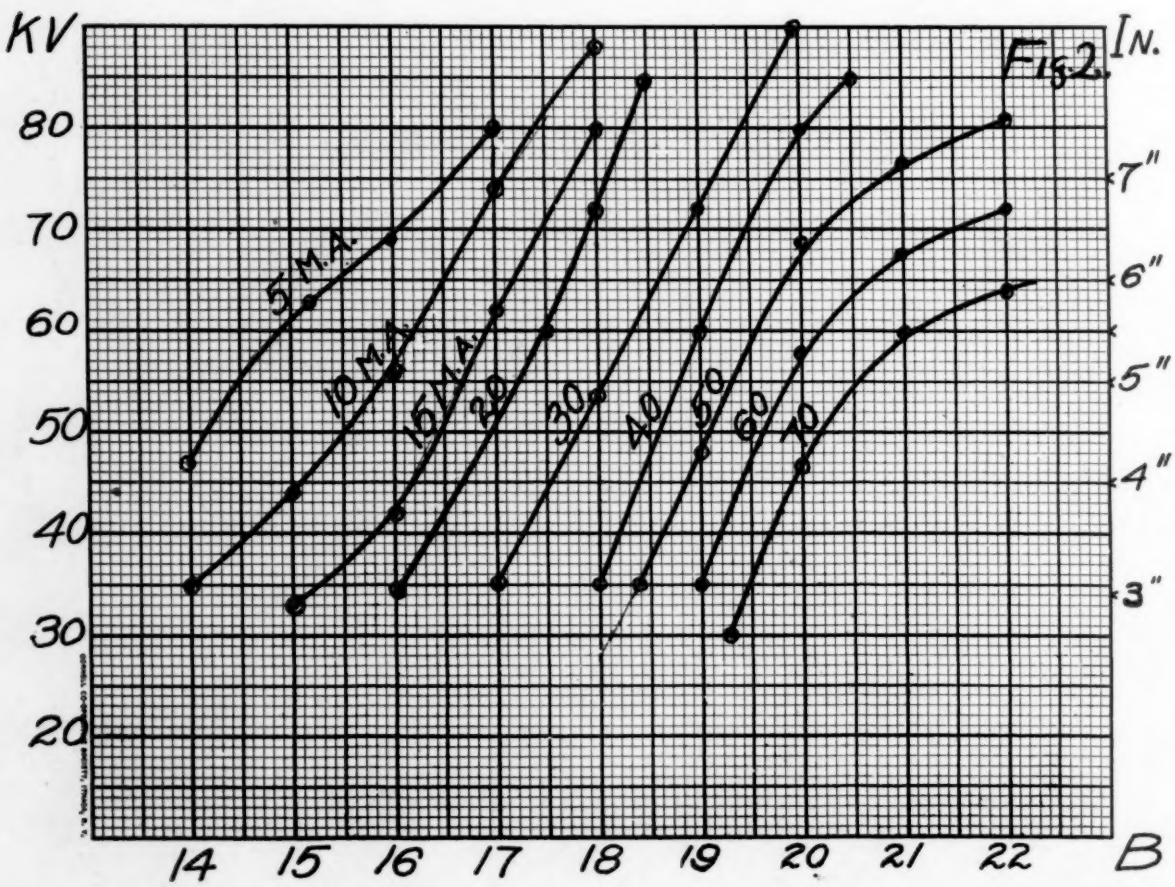


given tube carries a definite current at a definite voltage it develops Roentgen rays of a fixed quality and at a constant and definite rate. Of the *two* factors *current* and *voltage*, the latter is the more important and should receive the more careful attention.

With a gas tube, one tests for a given spark gap and current on a low button, then cuts out resistance in the primary of the transformer and makes the exposure. In this case a reduction of rheostat resistance alters *both current* and *voltage*. With the Coolidge tube, after we *reach a saturation* current, only the voltage increases. Various instructions have been given for adjustment of the filament current and applied voltage for the new tube. Some have read the heating current through the filament. This is all very well for *small* tube currents such as are used in fluoroscopic or in treatment work but is not essential even there and is about useless for higher currents where a minute change in the heating current makes an entirely disproportionate change in tube current with a corresponding drop in effective voltage.

After testing all the advice given in this matter the following plan seems to work out best in the writer's experience. With a circuit of fairly *constant voltage* on the primary of the transformer the *voltage consumed* by the tube when it is passing a *given number* of *milliamperes* on a given rheostat setting *is equally constant*.

For example, if a Coolidge tube takes 30 M. A. on button 15 today its *equivalent spark gap* on the same button of the same machine will be the same with *this current* at any other time. We may find that a good radiograph of a given part is made with



40 M. A., 4″ spark, 24″ target-plate distance, 2 sec. exposure. If these conditions are taken again with the same make of plate the results will be identical. How is one to quickly and with certainty secure this setting again? Suppose one adjusts for a tube current of 5 M. A. and observes the spark gap on a series of *successive* rheostat settings. Then do the same for 10, 15, 20, 25, etc., milliamperes. It may be found that the various buttons, for example, give current-spark gap values as shown in Fig. 1. One can always feel sure, for example, that when the tube *again takes* 15 M. A. on button 12, the spark gap will be 3″.

A chart of this kind can be made once for all and no further readings are needed for any ordinary work. Thus if 40 M. A. with a parallel gap of 5½″ is required, a glance along the vertical line above 40 M. A. shows that button 19 must be used. Then set on 19 and adjust rheostat on filament current until 40 M. A. pass and the tube is ready for use.

Inasmuch as only *one careful* set of observations is needed one can well afford to make the chart on account of the great saving of time and certainty of results thereafter. Fig. 1 shows such a diagram for one of the machines in the writer's laboratory. For a fairly heavy knee 35 M. A.—4″ spark —24 inches—1.5 sec. on a certain plate gives a good negative. All we have to do is to put rheostat on button 18 and adjust filament rheostat until the tube is taking 35 M. A. which can be done very quickly. Neither *filament current nor spark gap* is read, in fact for radiographic work the gap is left at 8 inches for use solely as a safety valve. A filament current rather in excess is used when closing the switch and the rheostat resistance on the storage battery or transformer is quickly raised to give the desired tube current. We find that the use of fairly large currents at the lowest voltage giving requisite penetration will produce the best negatives.

If one prefers, the diagram can be made for *given currents*. Thus in Fig. 2, 10 M. A. on button 14 means a 3″ spark, on 16 a 5″, etc. To use the chart, simply decide on the *current* desired and choose the button giving the required penetration. A little time spent in this way will be a great saving in operating time, and in plates, and also give much more consistent results.

The given curves are plotted both with kilovolts (right) and spark gap (left). It must be noted that these apply only to the machine and spark gap in question. Care should always be taken to measure spark length when *changing from* a wide gap. After breaking at a 5″ gap the arc may *continue* through a 10 inch gap.

AMERICAN PRIORITY IN THE USE OF BISMUTH FOR THE EXAMINATION OF THE HUMAN STOMACH

By A. W. CRANE, M. D.

Professor Rieder (1) of Munich has been given universal credit for having first used bismuth in large doses mixed with food material for the study of the human stomach. Cannon (2) in America has been granted undisputed priority in the use of bismuth for the study of the stomach in animals six years before Rieder's work. Hemmeter (3) in a published article in 1896 suggested the use of bismuth for the X-ray examination of the stomach, thus securing to America priority for the idea.

But the fact seems curiously to have been forgotten that five years before Rieder's (1) publication in 1904, an American, Dr. Williams (4) of Boston, assisted by Cannon, on Sept. 23, 1899, gave an ounce of bismuth subnitrate mixed in a pint of bread and milk to a boy of 10 years for the express purpose of making an X-ray examination of the stomach. The examination was made by the fluoroscopic screen in the horizontal and also in the standing position. Tracings of the entire stomach were made and peristalsis and stomach emptying were watched at intervals for six and a half hours. Two other cases followed. In the third case a series of plates was made at intervals of from one to two hours until the stomach emptied.

The technique of the examination of these three cases would not be a discredit to a good Roentgenologist at the present day. It is interesting to note that Williams placed a penny in the umbilicus as an X-ray landmark—a procedure which is conspicuous in German plates five years later. Also Williams strongly recommends the screen in preference to the plate for the examination of the bismuth stomach, an opinion which has since found strong German confirmation.

This work of Williams is found recorded in his book, "THE ROENTGEN RAYS IN MEDICINE AND SURGERY." (The Macmillan Co.), 1901. This publication antedates Professor Rieder's publication by over three years. A remarkable lapse of memory regarding Williams' work is revealed by a volume of the Transactions of the American Roentgen Ray Society for the 6th Annual Meeting in the Johns Hopkins Hospital, Baltimore, 1905. In this volume is printed a brilliant address by Dr. Henry Hulst (5) in which he says, discussing Rieder's work: "There is nothing new in this use of bismuth subnitrate. Williams gave an ounce of bismuth in emulsion as early as 1897. * * * Williams' work was mainly fluoroscopic.

"The outline of the stomach," he remarks, "was better defined on the fluoroscopic screen because the stomach moves during respiration and, therefore, its outlines are blurred on the radiograph."

Dr. Hulst's paper was discussed by Drs. Leonard, Pfahler, Burdick and Dunham.

It is interesting to note that Leonard (6) of Philadelphia says, in this discussion: "I wish to correct Dr. Hulst in one particular from the historical standpoint. I demonstrated a case of gastroptosis before the American Medical Association in Philadelphia in 1897, in which the lower curvature of the stomach was in the pelvis."

If Leonard's demonstration was made by means of a contrast-meal, then American priority is multiplied.

So important and interesting are Williams' observations that they deserve to be

quoted at some length. The following is extracted from "THE ROENTGEN RAYS IN MEDICINE AND SURGERY," by Francis H. Williams, M. D., 1901. "Some substances opaque to the X-rays, such as an emulsion of subnitrate or metallic bismuth, may be poured into the stomach through a stomach tube; or powdered subnitrate or metallic bismuth may be mixed with the food—the latter is more opaque to the rays than the former—and the size, shape and position of this organ watched on the screen. I have not tried all of the various methods alluded to, but have found the one which I have used, namely, the mixture of subnitrate of bismuth with food quite satisfactory. My first observations were made four years ago with this salt, the use of which would naturally suggest itself to any one who was seeking a substance opaque to the rays and harmless to the patient. If the practitioner does not wish the bismuth to pass on into the intestines, the stomach may be freed from it by means of the stomach tube after the observations on the stomach have been made. Subnitrate of bismuth has been used in making these examinations, and, so far as I am aware, no untoward results have been caused by its use; it is non-irritating and non-poisonous, and a large or small percentage of it may be used, as desired; a preparation must be employed that is free from any trace of arsenic and that is perfectly pure.

"An ounce of subnitrate of bismuth, well mixed with food, such as bread and milk, should be given to the patient when everything is ready for the examination. The food should be stirred from time to time while the meal is being taken, or perhaps better, some of the bismuth which has settled in the bottom of the bowl may be dipped up with each spoonful.

"The further procedure may be noted in the description given of the cases observed.

"Two or three years ago Dr. W. B. Cannon, then a student of the Harvard Medical School, who had made some excellent observations on the digestion of cats, assisted me in some observations on the stomach of two children, the elder of whom, James W., was ten, and the younger, M. W., was seven years of age. As a rule the children were lying on their backs on the canvas stretcher already described; the target of the vacuum tube was 45 to 60 centimetres from the under surface of the body at a point under the umbilicus, and the fluorescent screen was placed over the abdomen. The outlines observed were traced by one or other of the methods already detailed, that is to say, either on the thin sheet of glass or celluloid which covered the screen, by means of a lithographer's pencil, or directly on the skin by means of a clinical pencil, and then copied on to tracing cloth for permanent record. After the first tracings were made the glass or celluloid was washed and used again, or the skin was washed with alcohol and thus made ready for another tracing, according to the method adopted.

"The results of our observations fall naturally into three divisions: First, the position of the stomach and the difference of position obtaining between the standing and the prone positions; second, the movements of the stomach in respiration; and, third, the changes in the shape of the stomach during digestion.

POSITION OF THE STOMACH WHEN STANDING AND LYING DOWN.

"Saturday, September 23, 1899, James W., ten years of age, was examined with the X-rays during digestion. He finished eating a pint of milk into which bread had been broken, with which nearly an ounce of subnitrate of bismuth had been mixed at 2:56 P. M. The tube in this case was 53 centimetres from the boy's back. A coin, which cast a shadow on the screen, was placed over the umbilicus to mark the position of the latter. At 3:30 P. M., the lower border of the stomach was on a line with the umbilicus; at 5:00 P. M. 1.5 centimetres above this point. During this time the boy was lying on his back.

"He was then examined, at the latter hour, when standing, and in this position the

lower border of the stomach was 1.5 centimetres below the umbilicus; that is to say, with the change of position in the boy, there was a difference of 3 centimetres in the position of the lower corner of the stomach." * * * *

CHANGES IN SHAPE OF STOMACH DURING DIGESTION.

"A third child, K. A., five years of age, was recovering from typhoid fever when I examined his stomach with the X-rays. The procedure was as follows: He was given 2 drachms of castor oil in one day in order to empty the bowels, and the bowels moved that day and again the next morning. At 11:00 A. M. on the latter day he ate a bowl of bread and milk mixed with 6 drachms of subnitrate of bismuth. He was then examined by means of the fluorescent screen, and photographs were taken at intervals of one or two hours for several hours after the meal, the plate being placed on the front of the body. The radiograph, taken 3½ hours after the meal, showed that the area of the stomach was dark and its outline was best defined at its greater curvature, but this outline was still better defined on the fluorescent screen because the stomach moves during respiration and therefore its outlines are blurred on the radiograph. The vertebrae which were directly behind the stomach could not be seen. The area to the left of the stomach was free from bismuth and showed as a light place on the radiograph. A coin was placed directly over the umbilicus as a point of reference, and its shadow could be seen in radiograph. The next radiograph showed that the bismuth had been widely distributed through the abdominal cavity, and that it had gone down into the pelvis to some extent. The image of the coin was almost obscured.

The last radiograph, made 5½ hours after the meal, showed that there was no food in the stomach, and that the great mass of it was on the left side, low down, and had reached the region of the left ileac fossa. The parts which had been dark were now nearly as clearly defined as normal, notably the vertebrae behind the stomach. The next morning the dejections had the color characteristic of bismuth. * * * "

Williams' book contains thirteen cuts of stomach tracings after bismuth meals. He continues: "Thus we see that if bismuth is given as described above, an outline of part of the stomach, its position in inspiration and expiration, and some peculiarities of shape may be noted; likewise that its changes in respective rapidity with which digestion proceeds in different individuals may be watched. After the various characteristics belonging to the stomach in health have been established, the presence of abnormal conditions of this organ, such as some cases of malignant disease, will perhaps be more readily recognized than at present. The constant presence of a darkened area in the stomach, for example, may suggest the thickening of its walls due to a malignant disease; some displacements or adhesions may be recognized as well as hourglass contractions, or an unusual delay of the digestive process.

"X-ray photographs do not show the movement of the stomach which takes place from expiration to deep inspiration. The photographic plate, or the screen, whichever is employed, should be placed over the abdomen, not on the back, when an X-ray examination is made."

On page 357 I find the following under "Oesophagus:"

"DIVERTICULUM—A diverticulum may be recognized if its position is a favorable one by means of the following method: Bismuth is mixed with the food, and when the patient has eaten the mixture his throat is watched on the screen. If the bismuth lodges in the diverticulum, the position of the latter may be pointed out in some instances. Or a rubber tube filled with shot or mercury may be inserted. If the sound finds the opening, the position of the diverticulum may be seen on the screen."

Williams acknowledges the work of Roux and Balthazard (7) on frogs, dogs and men. This work was done with bismuth and water and its publication, 1897, antedates the pub-

lication of Cannon in 1898. But Cannon's observations were actually made and attested before Roux and Balthazard made their experiments. Priority, however, in the use of bismuth and water in the X-ray observation of the lower border of the human stomach is secured by Roux and Balthazard. The quantity of bismuth was too small to make the method of any practical value and it remained for Williams and Cannon first to give large doses of bismuth subnitrate mixed with food and actually to make clinical examinations of the human stomach.

In the three and a half years that elapsed between Williams' book and Rieder's paper, a great advance had been made in the use of X-ray plates. Rieder's ability to make quick exposures and to obtain clear-cut stomach negatives enabled him to give us the splendid work that bears his name. He put old wine into new bottles.

I am not aware that Williams' work on the stomach is mentioned by German authors, although his book which contains it is duly listed in Gocht's (8) Die Rontgen-Literatur, 1911-1912, I and II Band. Groedel (9) says, "Already in the year 1897 the results of the earliest investigations were published. Independently of each other Cannon and Roux and Balthazard reported observations on bismuth-holding food. Among later authors who led in a similar manner should be named O. Kraus and Lormmi. To be sure Roux and Balthazard had already employed the method on men, but the result was nevertheless unsatisfactory. Even so the experiments which were undertaken on the other side in this or similar directions gave only relatively trifling profit. A change first began when it was made possible for us after the work of Rieder by the use of large quantities of a metallic salt to make the human stomach and digestive canal Roentgenologically visible and photographable."

Kaestle (10) in the Roentgenkunde of Rieder and Rosenthal says, "Hildebrand and Becker used bismuth water for Roentgenologic discovery of the lower border of the stomach as also did Roux and Balthazard who first observed peristalsis by the Roentgen ray. Rieder brought the whole human stomach first to Roentgenological representation when he had patients, before X-ray exposure, eat a stiff pap to which he had added as a contrast means a large quantity of bismuth subnitrate.

"In animal research before Rieder, Krause, Cannon, Roux and Balthazard had already used a similar procedure."

Groedel's veiled reference to "experiments which were undertaken on the *other side* in this or similar directions," and also Kaestle's reference to Cannon do not impress me as frank recognition of good work done outside of Germany.

A volume of transactions of a medical society is a lead-lined sarcophagus for the preservation of ideas in a state of suspended animation within the vault of a library. Mendel's epoch-making paper (11) on heredity slumbered for 35 years before its resurrection. If Hulst's paper had been published in a circulating journal it is safe to say that Williams' work would not have fallen out of the sight and thought of his X-ray countrymen.

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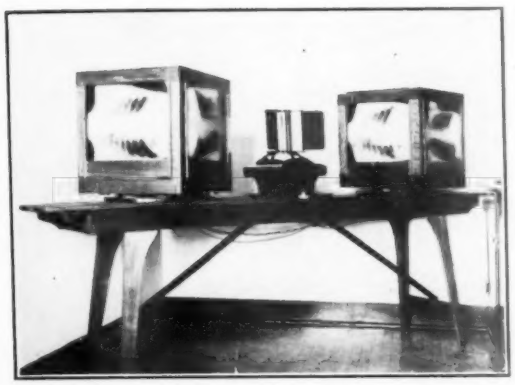
AN INEXPENSIVE MULTIPLE STEREOSCOPE AND FLUOROSCOPE

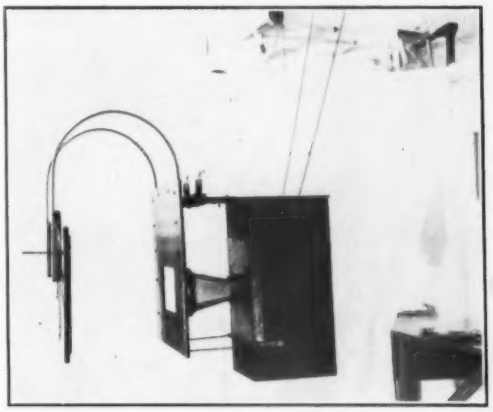
By HOMER L. SAMPSON, Adirondack Cottage Sanitarium, Trudeau, N. Y.



When viewing radiograms, whether stereoscopic or otherwise, one finds the need of making comparative analysis of similar cases, and to do so it is a great convenience to be able to compare plates with as little changing as possible. With the stereoscopic view-boxes for chest plates commonly on the market, this is not readily accomplished, as they hold but one pair of plates at a time, and to compare these plates with another set requires the removal of the first. To facilitate comparative analysis, we have constructed a multiple (four-sided) stereoscope. By simply revolving the boxes, this apparatus permits the comparison of four sets of plates without change. Being built almost entirely of hardwood, the low cost of construction is another advantage.

The stand is made of ⅞-inch oak and is 3 feet high, 8 feet long and 16 inches wide. The platform is composed of four strips of ⅞-inch oak running the length of the stand. The two center strips are 4 inches wide, with a 2¼-inch space separating them. The space between each center and outer strip is 1 inch. These outer spaces accommodate wooden guides on the upper side of auxiliary platforms upon which the revolving boxes rest. On the top of the two outer strips are steel runners, upon which the auxiliary platforms, fitted with rollers, move to and from the mirrors. The view-boxes revolve around stationary lights (preferably tubular bulbs). To permit this, the auxiliary platforms mentioned above were built under each box. In the center of each of these platforms a short piece of 1½-inch piping is fitted. On the bottom of the view-box itself is fastened a metal collar in which is screwed another short piece of 1-inch piping. This fits into the piping of the auxiliary platform. On the top surface of the auxiliary platform are screwed four sash rollers. These bear the weight of the view-boxes and facilitate easy manipulation. This completes the bearing on which the boxes revolve, and it is possible to rotate the view-boxes without moving the auxiliary platform. To the under surface of the auxiliary platform a strip of band steel ½-inch wide is fastened, bent in such a manner as to run through the two short pieces of piping and into the view-box.

A half-tone is shown of a very inexpensive fluoroscopic device, and, if we may say so, one that is simple and efficient. The



novice mechanic can construct it with very little difficulty. At the front is seen the fluoroscopic screen, mounted on two sliding rods which are fitted into two short pieces of metal tubing in the front of the arches. This makes possible the adjustment of the screen for different depths of chests. The arches are made of band steel, one inch wide, of sufficient thickness to insure fair rigidity. The back ends of these bands are bolted to a piece of ⅜-inch veneer (the latter material is used to obviate warping) upon the back of which are mounted brackets to hold the box that contains the tube. The square of veneer measures about 22 x 22 inches, with a rectangular opening in the lower two-fifths sufficiently large to allow for the full illumination of the screen. The anode of the tube (in box) is about 15 inches from patient. Lead, ⅛ or 1/16 of an inch in thickness, for protection, can be mounted on the tube box or veneer square. Naturally, less is needed on the former, and when placed here the weight of the apparatus is less. Proper insulation should be used for the wires leading into the box.

The whole apparatus is suspended. Sash-cord is fastened at the proper points on the box and runs upward to two ball-bearing pulleys in the ceiling, and from these to two more pulleys near the wall. From these latter pulleys the sash-cord suspends a weight corresponding to that of the fluoroscope. With ball-bearing pulleys, the up and down movement is minimized to a lift of four or five pounds.

A handy feature of the apparatus is the easy lateral motion, so convenient in chest examination when watching for changes in fluid levels.

Diaphragms or cones, for cutting down the field of examination, can be mounted with little or no difficulty, either to the back of the veneer square or to the front of the tube box, preferably the former.

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EDITORIAL

A recent experience which came under the editor's notice illustrates most vividly the difficulties of differential diagnosis. The average Roentgenologist usually feels called upon to express a definite opinion as to the classification of the bone pathology which is presented. That such a differentiation is sometimes impossible, and should never be indulged in without due consideration of all the factors in the case, is graphically illustrated by the following history:

A patient who had contracted lues early in life, after a lapse of fifteen years had pain in the side accompanied by slight elevation of temperature, preceded, usually, by rigor. A destructive process was found roentgenographically in the posterior aspect of the seventh rib and after some watching, was excised. The clinical and Roentgenological diagnosis before the operation was gumma. The microscopic examination made by a most competent pathologist was hypernephroma. After a lapse of time a destructive process was found in the left ilium. A subsequent examination of the tissue removed from the rib, by three different pathologists in various parts of the country revealed a difference of opinion from the first diagnosis, in that the subsequent examinations were reported as gumma. All of these microscopical reports were made by men of unquestioned standing and two of them of national repute.

If there is such a disagreement among skilled laboratory men as to microscopic findings after the tissue has been removed and subjected to ordinary laboratory tests, it certainly behooves the Roentgenologist to render a positive diagnosis with circumspection.

ABSTRACTS

Lindsay, W. S., M. B., Ch. B.: A Method for Localization of Bullets. (Brit. Med. Jour., April 10, 1915, page 631.)

The bullet is localized on the screen, say in the thigh. An opaque object is placed beneath the thigh so that its center corresponds with a definite point in the bullet; for convenience he selects the point. Another body is similarly placed on the upper surface of the limb. The center of the lower object, the point of the bullet and the center of the upper object then lie in a straight line. The X-ray bulb is shifted a definite distance, for example, three inches, and a plate taken, the plate being in contact with the upper object and being horizontal. The positions of the two surface points are then marked with a skin pencil before the two objects are shifted. These marks can then be made permanent by scratching with a sharp needle. (Fig. 1.)

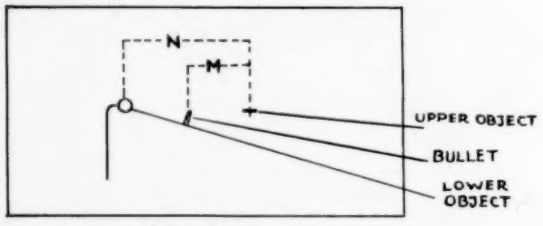

FIG. 1

The measurements m and n are made, m representing distance from the shadow of the upper object to that of the bullet, and n the distance between the shadows of the two opaque objects. We require also to know the distance of the anode from the upper surface of the X-ray table, but this is a constant for all exposures, let it be represented by b, and let a represent the distance the bulb is moved. Then the bullet lies in the line between the two points marked on the skin and at a distance from the anterior mark equal to

$$\frac{bm\ \ (a+n)}{a\ \ \ (a+m)}$$

If the bulb be moved three inches, if the anode be twelve inches beneath the upper surface of table, and if m=1 in., and n=3 in., then

$$\text{Depth of bullet} = \frac{12\times1\ \ (3+3)}{3\times\ \ (3+1)} = \frac{12\times6}{3\times4} = 6 \text{ in.}$$

The measurements can easily be made with an accuracy of one-sixteenth of an inch, and in no case, experimental or otherwise, did the error after calculation exceed one-eighth of an inch.

The advantages which it appears to Lindsay that this method has over that described by Lieutenant Mackenzie are:

1. The original ray by which the objects are placed in alignment need not be absolutely vertical, and so time is saved in adjustment. The distance A C (Fig. 3) is measured vertically, but any probable deviation from the vertical will make so slight a difference in A C that the error is negligible.

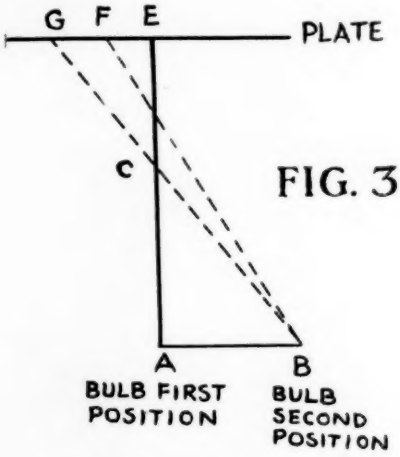

FIG. 3

2. The limb may be in any position of rotation that is most convenient at the time of the operation, as the two ends of the line are marked, and not only that one from which a perpendicular must be dropped.

3. As the calculation is made mathematically, there is no chance of error from an inaccurate drawing.

4. There is no necessity of measuring the diameter of the limb, for which a pair of calipers would be necessary.

But even with the bullet accurately located, there is frequently difficulty while operating in identifying a point in the tissues when only measurements are given. In order to locate this accurately, and to find the bullet without any unnecessary destruction of tissue, Lindsay devised an instrument. It consists of a frame, as shown in Fig. 2. All

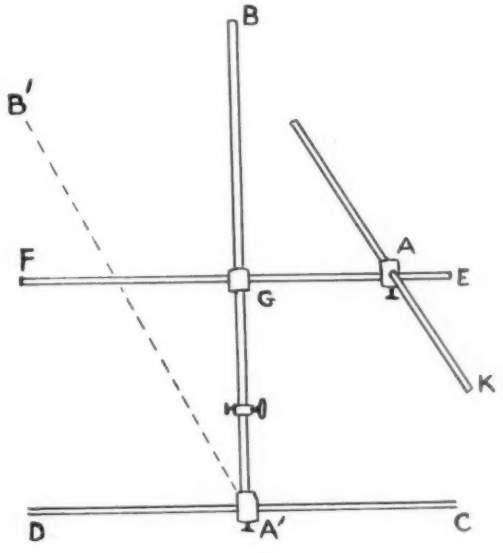

FIG. 2

the joints are sliding, and there is a hinge joint at A, so that the upright A B can be bent backwards into position A B. The bar E F is adjusted so that when C touches the posterior of the two points marked on the limb, E touches the anterior; H K is a light pointer, and is fixed to the bar E F by a sliding joint, and the pointer can be rotated and shortened or lengthened. It may be attached to the horizontal bar E F, or to the vertical bar A B. The point K is fixed in line between E and C, so that the distance E K equals that found by the above calculation. If, then, C touches the posterior point and E the anterior, K must be in contact with the bullet, for the bullet lies in the line E C at a distance from E equal to E K. The instrument is adjusted before the operation. The patient comes to operation having two points marked, the bullet lying in the line joining these points at a known distance from the anterior point; C is clamped to skin at posterior point, the upright bar being bent back so that K is out of the way. The upright is then raised in an attempt to bring E to the anterior mark. As this is done, the point K is obstructed by the tissues, and they are divided in front of it until E can be made to touch the anterior point. The tip of the pointer then touches the bullet. The instrument is most useful where one has cut down in the ordinary way to the point where one expected to find the bullet, but it is not there. By using this instrument, the exact point and direction in which the incision must be extended is indicated at once, and all unnecessary groping about is done away with.

The calculation by which the above formula is obtained is:

E F *in.* AB : AC = EG : EC, i.e., a : b = n : x + y.
E G *n.* AB : AD = EF : EF, i.e., a : b + y = m : x.
A B *a.* ax = bm + my.
A C *b.* i.e., ax - my = bm.
E D *x.* } both
D C *y.* } unknown
ax + ay = bn.
max + may = bmn.

$$a^2x - may \quad abm$$

add $ax\ (m+a) = bm\ (a+n)$.

$$x = \frac{bm\ (a+n)}{a\ (a+m)}$$

Johnston, G. C., M. D., and Grier, G. W., M. D., Pittsburgh, Pa.: A Device to Facilitate Radiography of the Stomach. (Interstate Medical Journal, June, 1915, vol. xxii, No. 6, p. 617.)

Johnston and Grier constructed a table, the top of which is made from a canvas army stretcher. A hole a foot square is cut

in the canvas top about its middle, so that when the patient lies prone upon the table, the abdomen protrudes through the hole. The canvas adapts itself to the contour of the body so that undue pressure is not made against the abdomen at the edges of the hole. A shelf below the hole, and adjustable in height to account for the varying distances that different abdomens protrude through the hole varies the plate or intensifying screen.

The first table built had only one pair of legs, the other end being hinged against the wall. With this table any degree of Trendelenburg posture is obtainable by merely raising and blocking the outer end of the table. When not in use, the table can be folded up against the wall.

Feeling the necessity for this device on a fluoroscoping radiographic table, they have laid the stretcher over the ordinary table-top. Blocks are fastened on the under surface of the stretcher frame to raise the canvas top five inches above the table-top, which the authors found to be a good minimum working distance between the two tops. Extra blocks are added when a greater distance is desired.

Barclay, A. E., M. D., Manchester, England: Roentgenological Studies of the Large Intestine. (Brit. Jour. of Surg., April, 1915, vol. 11, p. 638.)

The routine Barclay has adopted is to give a purgative thirty-six hours before, and an enema on the morning of, the giving of the first opaque meal. After this, apart from the giving of the opaque meal, the patient leads, as nearly as possible, his ordinary daily life, and observations are made from time to time, according to circumstances. At the first examination, watch the filling of the stomach and the manner in which it empties itself. Instructions are then given for feeding on the following day, at such interval before the second examination that one will expect to find the greater part of this second meal in the cecum. This will vary from three to seven hours, according to the rate of emptying of the stomach observed at the first examination. When the patient is again under observation, one should find in the colon the whole of the food given on the previous day, the head of the shadow being somewhere in the region of the splenic flexure. (When the shadow has passed well beyond this point, it is usual for the patient to have had a desire to defecate, or to have actually passed a motion.) The food given, say seven hours before, should be in the cecum and ascending colon, with a comparatively small amount in the last coils of the ileum.

In Barclay's opinion, it is advisable to use as little of the opaque mixture as is compatible with obtaining clear definition in the picture, and also that the excipient should be a *real* food. Bread and milk, into which the barium sulphate is mixed, is what he employs, and it gives good results. Suspensions of opaque salts are, in his opinion, to be avoided, for the reason that they quite needlessly introduce a possible source of error. The same applies to the massive doses of six or eight ounces of opaque salts that are sometimes given. Two or three ounces with each of the opaque meals is ample.

The anatomy of the large intestine, shown radioscopically, gives a picture of a more or less uniform tubular organ with regular haustral segmentations, from the cecum to the pelvic colon. One sees no evidence of any sphincter between the cecum and ascending colon; in fact, one has developed the habit of thinking of the cecum and ascending colon as one organ. For whenever any tendency to distention and "sloppiness" is seen, it seems to involve the whole organ as far as the hepatic flexure.

The hepatic flexure is much lower than one expects; it hardly reaches the level of the umbilicus when the patient is standing, and frequently gives the impression of being prolapsed. The splenic flexure ascends to a very high level into the dome of the diaphragm, the actual angle often containing a collection of air that is as closely related to the diaphragm as the fundus of the stomach.

Both flexures look, at first sight, as if they were acute angles in the gut, but this is not so; it is due to foreshortening of the two limbs of a U-shaped bend.

The transverse colon is far from horizontal. Its general direction is at an angle of 45° up to the splenic region; but there is almost invariably a loop that drops down to a much lower level, where it is sometimes fixed by adhesions; occasionally it is displaced upwards.

The descending colon drops straight from the splenic flexure to the iliac crest, and at this point becomes fixed by the peritoneum. In a proportion of cases, the descending colon drops down over this fixed point, and there is a tendency to kinking. This, Barclay believes, is the only point at which "kinking," apart from adhesions, occurs.

The only point about the anatomy of the sigmoid that strikes one is the close relationship that the loaded cecum and sigmoid may bear to each other. Sometimes they seem to be actually in contact.

Barclay has a series of cases that indicate another type of connection, i. e., a definite ileopyloric reflex, back from the terminal ileum to the stomach. In certain cases, duodenal irritation or ulcer type, the stomach began to empty very rapidly, overloading the small intestine. In a short time (say three-quarters of an hour), with a small quantity of food, the stomach was empty. And yet, when a reasonably large meal was given, it was found that, instead of being empty in the usual four hours, there was actual delayed emptying, and in some cases fully a half was still present after seven or eight hours. On again watching the progress of the food, one noticed that it was, so far as one could determine, when the shadows reached the terminal ileum, that this rapid emptying and general activity of the stomach ceased, and in each case there was quite well-defined ileal stasis, and very little, if any, food seemed to be passing on into the cecum. These observations give the impression that the terminal ileum is abnormal in some way, and that when once the food gets down to this point it causes a reflex closure of the pylorus and quieting down of the gastric activity, i. e., a message from a nervous center in the ileocecal region to the center in the duodenopyloric region, to the effect that as much food has come down as can be dealt with, and a request to shut off supplies. In nearly all these cases one found, at a seven hours' examination, that there was a complete gap between the food in the stomach and that which was collected in a mass behind the ileocecal valve. Those cases that have been operated on have all shown definite evidence of old inflammatory changes in the ileocecal region.

The importance of this observation is obvious, and throws new light on that curious manifestation—appendix dyspepsia.

Lane's kink Barclay has not recognized radiographically, and he is far from convinced that it is a cause of either ileal stasis or of this ileopyloric reflex.

Barclay concludes that the large intestine is only one of a closely linked-up system. That very wide variations, both as regards anatomy and physiology, are compatible with perfect health. That the ileocecal region is in very close association with the duodenopyloric region. There is evidence of two separate reflexes between the ileocecal valve and the pylorus, i. e., one from the stomach to the ileocecal valve, and another from the ileocecal valve to the stomach, the latter (the ileopyloric reflex) being responsible for appendix dyspepsia. Ileal stasis is, up to a point, physiological. Pathological ileal stasis is usually associated with adhesions in this region, most frequently appendicular in origin. In all these examinations it is essential to prepare and examine patients on a routine plan. A scheme that includes "double" feeding is useful. The appendix can be seen in a certain proportion of cases, and, by palpation, it can be detected whether it is fixed or lying free. The normal movement of feces through the large intestine is by "mass" movement, in which a large column is moved through a long section of the colon in a few seconds; these

movements take place probably some three or four times a day. The "mass" movements do not occur in the cecum. Constipation occurs as the result of stagnation: (a) In the sigmoid and rectum, i. e., inefficient defecation, or dyschezia; and (b) in the cecum, constipation proper. Constipation proper is probably the result of a defect in the mechanism of the "mass" movement. It is suggested that for the efficiency of this movement it is necessary that a sphincteric contraction should be present. The competency or otherwise of this sphincter, or *point d'appui*, determines whether the "mass" movement, when it occurs, propels all the feces forwards, or sends some of them back into the cecum. The large, sloppy cecum is the *result* of this inefficiency, and not the *cause* of constipation.

The opaque meal seldom gives information as to early neoplasms of the large intestine—it is only after the bowel becomes distended that information is obtained in this way. All suspected cases of neoplasm of the large bowel should be investigated by means of the opaque enema.

Callender, George R., M. D., Fort Bayard, N. M.: Roentgenography in Pulmonary Tuberculosis. (Interstate Medical Journal, June, 1915, vol. xxii, No. 6, p. 598.)

Callender emphasizes that roentgenography shows the reaction of the organism to disease and indicates the past history, but it will not decide the question of activity. A mossiness or irregular blending of the borders of shadows with the surrounding lung is considered to indicate activity, while sharply circumscribed shadows are considered to indicate healing. This conception has good theoretical foundation, as well-healed foci surrounded by a wall of fibrous tissue should give a sharply outlined shadow, while the induration about an active process is necessarily irregular and composed of tissues of different densities. Nature, however, is not constant in her methods of finishing the operation of healing, and we are not justified, as experience has adequately shown, in considering these signs as absolute unless physical examination supports them.

Callender would not assume, in the absence of clinical manifestations, that every marked shadow indicates active tuberculosis. In advanced lesions, fibrosis is indicated by dense shadows, the density of which is in proportion to their thickness and which frequently give shadows more dense than bone. Cavities show as annular shadows of varying intensity with more or less clear centers, depending on the character of the wall and surrounding tissues. The annular shadows of thick-walled cavities are homogeneous in appearance, while those of recent and thin-walled ones are delicate lines made up of fine nodular markings. If the lung is very thick and fibrous, or the pleura thickened by an adhesive pleurisy, cavities are somewhat obscured, but in the majority of cases, though one may be in doubt as to whether a given focus is fibrous or caseous, the annular shadows representing cavities offer a diagnosis of this condition approaching certainty.

Acute general miliary tuberculosis gives a very distinct picture when the lesions have advanced enough to interfere with the penetration of the ray. Early in the disease, when the lesions are universal and very small, occurring only in terminal capillaries, death may occur before changes can be demonstrated on the plate, or the patient may be too weak to allow the roentgenogram to be made. Roentgenograms of this condition show the lung covered with delicate fleck-like shadows of minute size and closely approximated. This appearance is seen in no other condition, and is diagnostic.

A thickened pleura and pleural adhesions cast shadows in proportion to their thickness and density. A generalized adhesive pleuritis gives a diffuse clouding of the whole picture with denser striations, particularly at the locations of the interlobar fissures. Localized pleural thickenings show as uniform bands and radiating striations.

The position of the mediastinum and heart may be influenced by adhesions, compensatory hypertrophy of the better or sound

lung, exudates and pneumothorax. The roentgenogram alone will clearly indicate the cause of such displacement as well as the exact position of the displacing factor, and that of the displaced structures.

Roentgenograms taken with the patient in the horizontal position show exudates as a diffuse clouding, but in the vertical position the line of the fluid is shown. This fluid line is very sharp if there is air as well as fluid in the cavity, while if no air is present the air-containing lung projects for some distance into the fluid and renders the line more or less indistinct and irregular. Localized collections of fluid, as in encapsulated interlobar pleurisy, are identified by their contour and position in the lung.

Pulmonary syphilis gives a picture quite distinct from that of phthisis. The shadows, as in the same disease in bone, are clear-cut and sharp, with no tendency to mossiness of the borders, and the disease can be readily diagnosed by the roentgenogram. In tumors of the lung, the shadows are homogeneous in appearance, and lack the linear markings of the tuberculous lesion. The picture is quite distinct, especially in advanced conditions, and once seen can be easily diagnosed.

Aneurysms are shown on the plate, but it is better to view suspected cases with the roentgenoscope for the presence of expansile pulsation. Fine details cannot be seen on the roentgenoscopic screen.

Case, James T., M. D., Battle Creek, Mich.: The Necessity for a Constant Technic in Roentgenography of Bone and Joint Lesions. (Interstate Medical Journal, June, 1915, vol. xxii, No. 6, p. 584.)

The errors that occur in the interpretation of roentgenograms depend upon variations in tube-plate, tube-body, and body-plate distance; upon variation in the angle of incidence of the normal ray, due to moving the tube laterally, or distally, or proximally from the position where the normal central ray falls vertically upon the center of the plate; and upon variations in the anatomical relations of the part studied. This latter factor may be due to restraint placed upon the patient by dislocation, separation of fragments, pain, etc., which prevent him from placing the injured part in the position usually accepted as the constant.

If one attempts to correct the possible error under these circumstances, by comparing the roentgenogram of the injured part with that of the sound part, it is of the highest importance that the roentgenogram of the normal part should be made with exactly similar technic. Therefore, if the patient, by reason of pain, dislocation or deformity, cannot place the injured part in the position accepted as the constant, it is important that the roentgenogram of the normal part for comparison be made, not in the normal or standard position, but in the position the patient was obliged to assume for the injured part.

Many of the disadvantages incident to the inherent disproportion in the shadows recorded on roentgenograms are overcome altogether, or at least minimized and unified, by the adoption of a constant technic in roentgenographic work. It is not sufficient that each individual roentgenographer should adopt a technic which is uniform in his own practice, but different from that of other Roentgen ray workers, but the various men responsible for Roentgen ray work should seek to employ the same standards as to target-plate distance, quality of tube, angle of incidence of rays, and especially the disposition of the part to be rayed.

More important yet, it appears to the writer, is the adoption of the stereoscopic method, and he, therefore, strongly recommends the uniform adoption of the stereoscopic method wherever it is feasible. Only slight and relatively inexpensive additions to equipment are needed to permit this kind of work. In fact, by a little extra care, it is possible to make very serviceable stereoroentgenograms of the various bones and joints with an ordinary portable coil and wooden tube-stand. Especially when dealing with small parts, as the hand, the wrist, the elbow, and the ankle, for example, it is

possible to make two stereoscopic exposures side by side on a single five by seven inch plate, viewing the stereoroentgenogram thus produced, in an ordinary hand stereoscope. Larger plates are, of course, needed for properly depicting some of the parts just mentioned, but the additional steroscopic study, possible with such little effort, is very helpful.

It is furthermore impossible to make plates of the shoulder or the hip in two directions, and often very difficult to make them laterally in injuries of the lower spine and sacrum, especially of the sacro-lumbar and the sacro-iliac joint. It is imperative in studying these parts that stereoscopic studies be made. In fact, with the possible exception of the long bones where roentgenograms in two directions are nearly always possible, the stereoscopic method is preferable for all joint and bone lesions. A constant standard of technic in the making of the single plate, as well as in the stereoscopic method, is the solution of the difficulties arising from errors in the interpretation of Roentgen plates.

THE HIP-JOINT: The hip roentgenogram should always be made stereoscopically. With the patient lying flat upon the back, the tube should be centered over a point in Poupart's ligament, midway between the anterior superior spine of the ilium and the pubic spine. Two exposures should then be made, one with the tube an inch and a quarter internal, and one with the tube an inch and a quarter external to this point. The tube-holder should be tilted slightly with each exposure, so that the central ray will fall exactly at the middle of the plate-holder, which is placed underneath the hip-joint.

In thin individuals, it is a good plan to use a sufficiently large plate to include the entire pelvis. With hip fractures, there is often an injury to the bones of the pelvis which would be missed if one used too small a diaphragm. In heavier individuals, where a small diaphragm is essential for good roentgenographic results, several roentgenograms should be made covering the entire pelvis. It is always important that the feet should be placed with the toes pointing directly upward.

THE KNEE: The knee-joint may be studied in five or six directions. Ordinarily, one makes a postero-anterior and a lateral roentgenogram. These suffice. The postero-anterior roentgenogram, that is, with the patient prone, patella upon the plate, the ray passing through the knee from behind forward, is preferable. The rays should enter from an angle slightly below the patella. Whenever possible, the patella should be next to the plate. If, for any reason, the patient cannot be moved, it is sometimes necessary to make the plate antero-posteriorly. If so, the patellar shadow is much enlarged and its finer detail is lost.

Lateral plates may be made with the plate internal or external to the knee, as the circumstances demand. Oblique illumination of the knee is sometimes very helpful. The oblique illumination may be made in several directions.

In lateral studies of the knee-joint, it is sometimes inadvisable to turn the patient, especially when there has been a fracture. Under such circumstances, the roentgenogram may be made by placing the knee within a right-angled plate-holder, the plate being held vertically to the inner side of the knee. The tube-holder is so adjusted that the tube is placed sideways, the rays traversing the knee laterally.

THE ANKLE: An adequate study of the ankle-joint requires three roentgenograms, one stereoscopic pair laterally and one single plate posteriorly. For the posterior plate, the exposure should be made with the leg resting on the long arm of a right-angled foot-holder, the foot being held in place by a few turns of an ordinary bandage. The central ray should enter the ankle at a point about one inch above the center of a line joining the tips of the malleoli. The tube should be tilted slightly downward in order that the central ray may traverse the clear space of the ankle-joint.

Lateral roentgenograms of the ankle are best made with the plate internal, the cen-

tral ray being focused upon the external malleolus. If stereoroentgenograms are desired, and they are, of course, preferable, the exposure should be made from a point one and a quarter inches to each side of the external malleolus.

THE SHOULDER-JOINT: Shoulder plates may be made anteriorly or posteriorly. In the average injury, it is usually more convenient to make the plates posteriorly. Because of inability to make exposures in two directions, stereoscopic roentgenograms are always preferable for shoulder work.

The patient should lie upon the back. The elbow should touch the table and the hands should be folded upon the abdomen. The central ray should be focused upon the head of the humerus and should approach the plate at right angles.

THE ELBOW: The elbow is usually studied in two directions. A single plate made with the arm extended, the palmar surface of the hand facing upward, and the olecranon process resting upon the plate, is usually read easily without the necessity of the stereoscopic effect.

The stereoscopic lateral studies are usually made with the plate against the internal condyle of the humerus (radio-ulnar), the arm being flexed almost to a right angle.

THE WRIST: Studies of the wrist should always be carried out by roentgenograms made in two directions. Stereoscopic studies are always desirable in investigating injuries to the carpal bones. The wrist and hand are placed with the palmar surface upon the plate. The central ray is focused over a point midway between the styloid process of the ulna and radius.

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